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ERP Implement Performance Evaluation of Power Supply Company Based on Gray Triangle Whiten Function

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Abstract

ERP plays an important role in company production and engineering management. With the wide application of ERP, the evaluation of its application performance is particularly necessary in order to constantly improve its implementation effect. ERP project performance evaluation is a holistic concept, which involves multiple aspects and needs to combine the qualitative and quantitative analysis. To assess the ERP implementation performance of Power Company, this paper firstly established a comprehensive evaluation index system. Secondly, the engineering evaluation model of ERP implementation performance was proposed based on gray triangle whiten function. Then, this paper described the ERP project implementation performance evaluation process. Finally, through the empirical analysis, the practicability and effectiveness of the proposed method was verified.

Keywords: ERP; performance evaluation; engineering; gray evaluation; triangle whiten functionare,

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1. Introduction

ERP—enterprise resource planning, which is a modern enterprise management method based on computer-aided information management systems, can make the production and operation activities and all aspects of information be a network system by using the modern information technology. Then, the logistics, capital flow, information flow of business activities can be effectively integrated to achieve the target of optimal allocation and sharing of corporate resources. It help enterprise improve decision-making efficiency and management level, and also reduce production costs greatly. Therefore, it is necessary to evaluated the implementation performance of ERP to make full use of this management method.

Although the research made by domestic and foreign scholars on the ERP implementation and corporate performance ratings were widely learned [1,2,3], it rarely get involved in the specific form and content of ERP implementation performance, as well as how to quantify the assessment of project performance. Therefore, a comprehensive evaluation index system of ERP implementation performance of power company is constructed in this paper, and a evaluation model based on gray triangle whiten function is applied to evaluate the implementation performance of ERP.

2. The establishment of ERP implementation performance evaluation indexes system of power company

2.1. The significance of ERP implementation performance evaluation

ERP implementation performance evaluation is an important part of power enterprise management, which helps companies make full use of ERP and adjust the bias in the ERP implement process efficiently, deepen understanding of the ERP, and speed up to the integration of ERP management information systems and enterprise management mode. The specific roles of evaluation include the following three aspects:

(1) Project control. In the Pre-ERP implementation phase, evaluation of enterprise resources can optimize resources allocation and choose the best ERP information system scheme. In the implementation phase, we need to clear the completion status of projects to determine how to take effective improvement action. In the ERP summary phase, we should determine whether the project is success, whether business process is optimized.

(2) Deviation correct. The evaluation may provide a range of criteria which can be used to correct deviations and coordinate the interests of all parties. In fact, the evaluation is not an end in itself, but is a mean used to gain a higher level of performance. The enterprise passes the project expectations to stakeholders, thereby affecting the behavior of these officers, which is the real significant of evaluation.

(3) The accumulation of knowledge. Through the application of evaluation system, it helps us grasp the key successful factors and accumulate the experience for similar projects, and improve the problem-solving abilities. It is a powerful tool which may enhance the practical ability and theoretical level and improve the level of system performance evaluation.

The procedure of ERP implementation performance evaluation followed by six stages is as shown in figure 1.

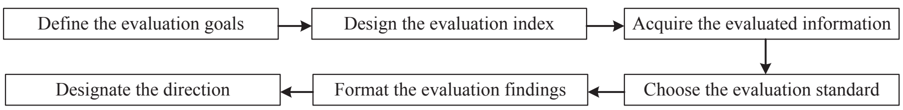

Fig. 1. The program of ERP application performance evaluation

2.2. The establishment of ERP implementation performance evaluation indexes system

Practice shows that ERP project performance evaluation is uncertainty and complexity [4,5]. It is a holistic concept which involves multiple aspects and indicators. In the evaluation process, we should extract the key factors from a variety of conflicted indicators. This paper analyzes the ERP implementation performance based on the quantitative and qualitative methods. The selection of ERP project performance evaluation indicators mainly abides the following principles:

(1) The indicators should be true and reliable. It cannot be repeated and contradictious among each other.

(2) The indicators should reflect the whole picture of enterprises including now, past and future. In addition, it is also needed to take surrounding economic environment and the government's industrial policy into account.

(3) The indicators should put the existing ERP project module content as the core of the evaluation. Quantitative and qualitative factors should be studied comprehensively to correct each other.

(4) The indicators should be as concise as possible. The redundancy of indicators will cause information overlap and interference. Therefore, the representative indicators should be selected to avoid the fact that the indicators are too numerous, conflict, contradict and so on.

Table 1. The smart grid safety evaluation index system

Criterion Layer		Index Layer	
A1	Financial Indicators	B1	Sales revenue
		B2	Rate of return on assets
		B3	Current ratio
		B4	Profit growth
		B5	Cost savings ratio
A2	Customer indicators	B6	Customer satisfaction degree
		B7	Customer loyalty degree
		B8	Rate of new customers obtains
A3	Operating efficiency indicators	B9	Rate of production plans achievement
		B10	Accounts receivable turnover
		B11	Improvement degree of decision-making level
		B12	Equipment management efficiency
A4	Learning and growth indicators	B13	Investment in staff training
		B14	Staff skills

3. The establishment of ERP implementation performance evaluation indexes of power company

According to Table 1, ERP project performance evaluation is divided into three levels. The total index A means the ERP implementation performance, which is composed of a set of evaluation index Ai and denoted by. $A=\{A1, A2, A3, A4\}$, where, the weights are $w=\{w_1, w_2, w_3, w_4\}$. B is composed of a set of evaluation index Bi and denoted by $B=\{B1, B2, B3,\cdots,B14\}$, where the weights are $w_i=\{w_{i1}, w_{i2}, w_{i3}, w_{i4}\}$.

The concrete steps of gray triangle whiten function can be expressed as follows.

3.1. Determining the weights of performance evaluation indicators

The relative importance of the indicators can be reflected by weight. The importance of each evaluation index is often different in multi-level assessment. The weights impacting the accuracy of evaluation directly should be set reasonable and scientific.. By using group decision-making method the weights will be determined, which is also called weighted average consolidated ordering vector method.

Assuming that the judgment matrix of experts is $A_k=(a_{ij,k})$, so the weight determined by each expert can be calculated. The weight given by expert k is expressed as $w_k=\{w_{1k}, w_{2k}, w_{3k},\cdots,w_{4k}\}$, $k=1,2,\cdots,s$. And the weighted geometric average integrated vector for all the experts can be calculated. $W_j=\overline{w}_j/\sum_{i=1}^{n}\overline{w}_i$, $\overline{w}_j=(w_{j1})^{\lambda_1}(w_{j2})^{\lambda_2}\cdots(w_{js})^{\lambda_s}$ $j=1,2,\cdots,n$, $\sum_{k=1}^{s}\lambda_k=1$. So $w_j(j=1,2,\cdots,n)$ is the weight of indicator j determined by group decision-making method.

3.2. Rank division

Four ranks are divided in this this paper, namely excellent, good, medium and poor., Each indicator should be assigned the score with five score principles 7o transfer the qualitative indicators into quantitative indicators. The four rating scores are excellent (4-5), good (3-4), medium (2-3), poor (1-2).

3.3. The establishment of evaluation matrix according to the evaluation indicators

Evaluators p were selected. and n denotes the number of the secondary level indicators. So ERP project performance evaluation matrix D_i may be constructed to get scores by Delphi method.

$$D_i=\begin{vmatrix} B_1 \\ B_2 \\ \vdots \\ Bn \end{vmatrix}=\begin{vmatrix} d_{11} & d_{12} & \cdots & d_{1p} \\ d_{21} & d_{22} & \cdots & d_{2p} \\ \vdots & \vdots & \vdots & \vdots \\ d_{n1} & d_{n2} & \cdots & d_{np} \end{vmatrix} \quad (1)$$

3.4. The establishments of triangle whiten function

(1) The range of each indicator can be divided into s gray types according to assessment requirements. The range of indicators B_i $[a_1,a_{s+1}]$ will be divided into $[a_1,a_2],\ldots,[a_{k-1}, a_k],\cdots,[a_{s-1}, a_s][a_s, a_{k+1}]$. Where, the value of $a_k(k=1,2,\ldots s, s+1)$ is generally determined on the basis of actual issues or qualitative research.

(2) Set $\lambda_k=(a_k+a_{k+1})/2$ equals 1,which belongs to the triangle whiten functionare value of k gray type. (λ_k,1) is joined with starting point a_{k-1} of $(k-1)$ gray type. So the triangle whiten function are

$f_k(*), k = 1,2,\cdots,s$ of B_i about k gray type can be ensured. For $f_1(*)$ and $f_k(*)$, the number field of B_i can be extended to a_0 and a_{s+2}.

For an observation r of B_i, the membership degree $f_k(x)$ of gray type $k(k = 1,2,\cdots,\ s)$ can be calculated by the formula (2).

$$f_k(r) \begin{cases} 0, r \notin [a_{k-1},\ a_{k+2}] \\ = \dfrac{r - a_{k-1}}{\lambda_k - a_{k-1}},\ r \in [a_{k-1},\ \lambda_k] \\ \dfrac{a_{k+2} - r}{a_{k+2} - \lambda_k},\ x \in [\lambda_k,\ a_{k+2}] \end{cases} \tag{2}$$

3.5. The calculation of the gray evaluation factor, evaluation vector, the evaluation matrix

Gray evaluation theory suggests that each assessor's score is a gray number. For indicator C_i, the scores of K gray type given by p assessor are $d_{i1},\ d_{i2},\ldots d_{ip}$. So the definite weights of C_i are $f_k(d_{i1}),\ f_k(d_{i2}),\ldots,\ f_k(d_{ip})$. The total definite weight of K gray type is $y_{ik} = \sum_{i=1}^{p} f_k(d_{it})$. The total definite weight of all gray type is $y = \sum_{k=1}^{s}\sum_{i=1}^{p} f_k(d_{it})$. Gray evaluation factor r_{ijk} can be expressed as $r_{ijk} = \sum_{i=1}^{p} f_k(d_{it}) / \sum_{k=1}^{s}\sum_{i=1}^{p} f_k(d_{it})$. The Gray evaluation vector can be expressed as $r_{ijk} = (r_{ij1}, r_{ij2}, \ldots,\ r_{ijs})$, where s is the number of gray type.

Let r_{ij} denote the gray evaluation vector, so the gray evaluation matrix R_i of indicator B_i can be ensured as follows:

$$R_i = \begin{vmatrix} r_{i1} \\ r_{i2} \\ \vdots \\ r_{i3} \end{vmatrix} = \begin{vmatrix} r_{i11} & r_{i12} & \cdots & r_{i1s} \\ r_{i12} & r_{i22} & \cdots & r_{i2s} \\ \vdots & \vdots & \vdots & \vdots \\ r_{in1} & r_{in2} & \cdots & r_{ins} \end{vmatrix} \tag{3}$$

3.6. Comprehensive evaluation

Let M_i denote the comprehensive evaluation result of indicator B_i, so $M_i = X_i \times R_i = (m_{i1}, m_{i2}, \cdots, m_{is})$ can be obtained as follows.

$$R = \begin{vmatrix} M_1 \\ \vdots \\ M_m \end{vmatrix} = \begin{vmatrix} m_{11} & m_{12} & \dots & m_{1s} \\ m_{21} & m_{22} & \dots & m_{2s} \\ \vdots & \vdots & \vdots & \vdots \\ m_{m1} & m_{m2} & \dots & m_{ms} \end{vmatrix} \tag{4}$$

$$M = X \bullet R = X \bullet \begin{vmatrix} X_1 \bullet R_1 \\ X_2 \bullet R_2 \\ \vdots \\ X_m \bullet R_m \end{vmatrix} = (m_1, m_2, \ldots, m_s) \tag{5}$$

3.7. References construction

The insurance of gray types grade is objective A according to maximum weight principle of evaluation. This paper will further process the gray comprehensive evaluation vector $M = (m_1, m_2, \ldots, m_s)$ and make M uniformization to prevent information losses, then calculate the comprehensive evaluation value V. Let $U = (\mu_1, \mu_2, \ldots, \mu_s)$ denote gray vector, so comprehensive evaluation value $V = M \times U^T$ can be calculated and sorted.

From the above description of multi-level gray comprehensive evaluation, we can find that dispersed information from multiple reviewers are described as different gray vector and uniformization. The results may not only ensure the grad of evaluation, but also may sort and select optimum according to comprehensive evaluation value when there are more than one evaluation object.

4. Empirical analysis

A power company has undertaken the enterprise information construction a number of years. Its ERP system applications range from financial, material, equipment, projects, human resources, customer relations and other core business, which is the platform to enhance the company management level, strengthen management and control operations, improve management efficiency and reduce operating costs. Using the proposed method of ERP performance evaluation, this paper analyzes and evaluates the ERP project implementation performance.

We determine the weights by group decision-making method. The results are as follows: the weight vector of the first level indexes $B_i (i = 1,,2,,3,,4)$ is $X = (0.3,0.2,0.3,0.2)$. The weights of the second level indexes are shown in Table 2 and Table 3:

Table 2. The weights of the second level indexes

indicators	C_1	C_2	C_3	C_4	C_5	C_6	C_7

weights	0.2	0.2	0.2	0.2	0.2	0.5	0.3
indicators	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}	C_{14}
weights	0.2	0.3	0.3	0.2	0.2	0.5	0.5

Table 3. The score of ERP implementation performance evaluation

score	4—5	3—4	2—3	1—2
standard	excellent	good	fair	poor

The sample matrix can be divided into four matrixes such as financial indicator D_1, customer indicator D_2, operational efficiency indicator D_3, learning and growth indicator D_4. Five experts are selected to score each indicator. The score sheet and sample matrix D_1 obtained by Delphi method are as follow.

$$D_1 = \begin{vmatrix} 3 & 3 & 3.5 & 3.5 & 2.5 \\ 2.5 & 3 & 3 & 3.5 & 3.5 \\ 3.5 & 3 & 3 & 2.5 & 2.5 \\ 3 & 3.5 & 2.5 & 3 & 3.5 \\ 3 & 3 & 3.5 & 3 & 3.5 \end{vmatrix}$$

D_2 , D_3 , D_4 are similarly available.

The evaluation ranks are divided into four evaluation categories, namely excellent, good, medium, and poor. Suppose $a_1 = 1$, $a_2 = 2$, $a_3 = 3$, $a_4 = 4$, $a_5 = 5$, $\lambda_1 = 1.5$, $\lambda_2 = 2.5$, $\lambda_3 = 3.5$, $\lambda_4 = 4.5$, we can establish the triangle whiten function as follows:

$$f_1(x) = \begin{cases} 0 & x \notin [0,3] \\ \frac{3}{4}x & x \in (0,1.5] \\ \frac{3}{4}(3-x) & x \in (1.5,3] \end{cases} \quad f_2(x) = \begin{cases} 0 & x \notin [1,4] \\ \frac{3}{4}(x-1) & x \in (1,2.5] \\ \frac{3}{4}(4-x) & x \in (2.5,4] \end{cases}$$

$$f_3(x) = \begin{cases} 0 & x \notin [2,5] \\ \frac{3}{4}(x-2) & x \in (2,3.5] \\ \frac{3}{4}(5-x) & x \in (3.5,5] \end{cases} \quad f_4(x) = \begin{cases} 0 & x \notin [3,6] \\ \frac{3}{4}(x-3) & x \in (3,4.5] \\ \frac{3}{4}(6-x) & x \in (4.5,6] \end{cases}$$

The total whiten weight of indicator C_1 belonging to the first gray type is $y_{111} = f_1(3) + f_1(3) + f_1(3.5) + f_1(3.5) + f_1(2.5) = \frac{3}{4}$. We can obtain the evaluation vector and the evaluation matrix.

$$R_1 = \begin{vmatrix} \frac{2}{23} & \frac{10}{23} & \frac{7}{23} & \frac{4}{23} \\ 0 & \frac{2}{11} & \frac{7}{11} & \frac{2}{11} \\ \frac{1}{10} & \frac{1}{10} & \frac{7}{10} & \frac{1}{10} \\ \frac{4}{23} & \frac{10}{23} & \frac{7}{23} & \frac{2}{23} \\ 0 & \frac{6}{23} & \frac{14}{23} & \frac{3}{23} \end{vmatrix}$$

The others are similarly.

The comprehensive evaluation result M_1 of B_1 is:

$$M_1 = X_1 R_1 = (0.2, 0.2, 0.2, 0.2, 0.2) \begin{vmatrix} \frac{2}{23} & \frac{10}{23} & \frac{7}{23} & \frac{4}{23} \\ 0 & \frac{2}{11} & \frac{7}{11} & \frac{2}{11} \\ \frac{1}{10} & \frac{1}{10} & \frac{7}{10} & \frac{1}{10} \\ \frac{4}{23} & \frac{10}{23} & \frac{7}{23} & \frac{2}{23} \\ 0 & \frac{6}{23} & \frac{14}{23} & \frac{3}{23} \end{vmatrix}$$

The others are similarly.

The ERP project performance evaluation results are available according to methods mentioned above. The gray vector is $U = (4,3,2,1)$. The comprehensive evaluation value is $V = M \times U^T = 3.7467$, which shows that the ERP project performance achieves good level.

5. Conclusion

This paper presents the ERP performance evaluation process of electric power engineering enterprise and establishes a comprehensive evaluation index system from four aspects financial, customer, operational efficiency, learning and growth, which may enable to achive the goal of project control, deviate correction, knowledge accumulation, in-depth understanding.

Gray triangle whiten function was chosen as the ERP project performance evaluation method. The processes were proposed and proved by empirical analysis. Gray comprehensive evaluation method may fully utilize the information of each evaluation index. It was used to describe the level of performance and do horizontal comparison. With wide range of practical and good operability, this method can apply to actual engineering work.

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